1986

Effect of chemical growth retardants on carbohydrate levels of turfgrasses /

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EFFECT OF CHEMICAL GROWTH RETARDANTS ON CARBOHYDRATE LEVELS OF TURFGRASSES

A Thesis Presented By
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Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE

FEBRUARY 1986

Plant and Soil Sciences

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ACKNOWLEDGEMENTS

I wish to express my gratitude to Dr. William Torello, Chairman of my thesis committee, for his generous assistance, constructive criticism and advice.

Thanks are also extended to Dr. J. Troll and Dr. S.J. Herbert for their helpful comments and cooperation.

Also appreciated are my parents for their patience and understanding, and most especially, Stephen Weiss for his love, encouragement and assistance throughout this endeavor.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Plant growth retardants (PGR) have been developed which reduce turfgrass growth, thereby reducing labor and mowing costs (2,4,5,6,7,8,9,10,14,15,16,17,22,27,28,29, 32,36,41). Several of these chemicals are currently available commercially but testing of these and experimental growth retarding compounds continues. Frequently, chemical growth retardants cause discoloration of intensively managed turf (5,6,7,9,15,16,17,22,27,28, 29,36,41). This phytotoxic response can be caused by over-application, or may just be inherent to the particular chemical used. Application of growth retardants immediatly prior to or during temperature or drought stress usually intensifies phytoxicity (14,28,41). Consequently, PGR use has been limited to low maintenance areas such as roadsides and locations that are hazardous or difficult to mow. The cause of injury associated with these chemicals and the compounding effects of environmental stress must be investigated before PGR's can be regularly used on intensively managed turfgrass.

Little information is available concerning the effects of growth retardants on total nonstructural carbohydrate (TNC) fluctuations in turfgrasses. Carbohydrates produced during photosynthesis are assimilated into nonstructural compounds such as reserve polysaccharides (fructosans) and proteins (1,19,25,30). In addition, nonstructural carbohydrates are used as a source of energy for the maintenance and growth of plant tissues (1,19,25,31). Decreasing or very low levels of TNC usually reflect the presence of environmental stress such as high temperature or drought (12,19,23,30,31,40,41). The level of TNC in turf naturally declines during the summer months rendering the turf more succeptable to injury or reduced recuperative potential. Since growth retardants are usually applied just prior to summer, they may predispose the turf to extensive environmental stress.

The primary objective of this research was to determine the effects of two chemical growth retardants (foliarly absorbed mefluidide, 3M Co., and root absorbed EL-500, Eli Lily Co.) on growth reduction, turfgrass quality, and %TNC content of turf when applied at various frequencies during the spring or fall season. The effect of temperature stress on %TNC content of turf treated with growth retardants was also investigated since turfgrasses are often subjected to high temperature stress during the summer months.

CHAPTER II

LITERATURE REVIEW

Chemical plant growth retardants (PGR's) have been used on turfgrass to reduce mowing maintenance requirements (2,4,5,6,7,8,9,10,14,15,16,17,22,27,28,29, 32,38,41). Although these chemicals retard grass growth and seedhead formation, they may, quite frequently, induce turf discoloration or phytotoxicity. Consequently, use of growth retardants has been limited to roadbanks or hazardous-to-mow areas where reductions in aesthetic quality of turfgrass can be tolerated.

Commercially available mefluidide (N-[2,4-dimethyl-5-[[(trifluoromethyl)sulfonyl]amino]phenyl]acetamide), trade name Embark, has been shown to reduce Kentucky bluegrass (*Poa pratensis* L.) topgrowth as well as inhibit seedhead formation (15,16,17,22,28,29,30,41). Another promising aspect is the ability of mefluidide to induce a shift in the utilization of photosynthate stored in annual bluegrass (*Poa annua* L.) away from seedhead production, and thereby reduce seedhead formation (41). Photosynthate may later be used during the hot summer months which could conceivably increase stress tolerance and possibly avoid

Poa annua brown-out (41). In addition, it has been reported that mefluidide has the potential to promote deeper Poa annua root growth. As such, annual bluegrass would be better suited morphologically to handle summer stress in view of an improved shoot-to-root ratio (41).

The mechanism of action by which foliarly absorbed mefluidide suppresses turf growth is not clearly understood. Growth of a grass blade takes place at its basal meristem through cell division and elongation, and it is in this area that mefluidide most likely regulates growth (41). Gerrish and Dougherty have proposed that cell elongation is inhibited more than cell division since mefluidide significantly limited expansion of newly emerged tall fescue leaves but had no effect on the rate of leaf appearance (10). Mefluidide was also shown to decrease tillering initially, but tiller populations seemed to increase later in the season (10). The inhibition of reproductive growth, and consequently, the weakening of apical dominance may have released more axillary buds to form tillers (10). These responses would agree with reports that mefluidide acts as an inhibitor of IAA metabolism (11).

Use of chemical growth retardant EL-500 (Eli Lilly Company, chemistry undisclosed) is still in the experimental stages. Watschke found EL-500 to be slower acting than mefluidide, but ultimately more effective in reducing growth of 'Merion' Kentucky bluegrass (29). The mechanism of action by which root absorbed EL-500 retards growth is currently unknown.

Both mefluidide and EL-500 cause a phytotoxic turf discoloration (14,15,16,17,27,28,29,30,32,36,41). Turf under drought or other stress will not respond well to treatment with mefluidide because the chemical will not be efficiently absorbed and translocated to the growing part of the plant, which may result in browning of grass (41). Hurto (14) reported that injury from EL-500 was more pronounced than from mefluidide and injury worsened during temperature stress.

Temperature has been correlated with seasonal fluctuations in carbohydrate reserves (12,19,33,34,37,40). Turfgrasses are often subjected to severe temperature stress during summer months. Prolonged periods of relatively high temperature cause photosynthetic and concurrent respiration rates to increase (20,23,30,31,37). At high temperatures the respiration rate usually exceeds the photosynthetic rate. When CO_2 fixation can no longer supply the metabolic demands (respiration) for carbon, carbohydrate reserves, primarily fructosans, are eventually depleated and growth ceases. Turf treated with mefluidide has been shown to accumulate a higher percentage of total nonstructural carbohydrate (TNC) than untreated turf (28). Watschke has suggested that this accumulation of TNC could provide growth capability during periods of temperature stress (28). Treated plots were shown to be greener than the check which is not uncommon for injured turf that is recovering (28,32,44). This "green-up" response may have resulted from utilization of stored photosynthate after dissipation of PGR effects (28).

Although progress appears to have been made in formulating compounds that are less injurious to turf without sacrificing growth regulating capacity, successful retardation of finely managed turf is not yet possible due to inherent phytotoxicity which is usually enhanced during environmental stress periods.

CHAPTER III

MATERIALS AND METHODS

Field Studies

Experiments were conducted in the spring and fall of 1983 on experimental turf plots having a mixture of Kentucky bluegrass (*Poa pratensis* L. Baron) and red fescue (*Festuca rubra* L. Pennfine). Experimental plots are located at the University of Massachusetts Experimental Turf Plots, South Deerfield, Massachusetts. Soil type is a Hadley Silt Loam (mesic Typic Udifluvents). Turf plots were fertilized in early May and late August with a 20-18-12 fertilizer at a rate of 48.8 kg N/ha. Dimethyl tetrachloroterephthalate (Dacthal) was applied on May 18 for preemergence crabgrass control. Oftenol was used on August 11 for Japanese beetle grubs, and Trimec on August 25 to control broadleaf weeds. Plots measuring 1.5 m x 3.0 m were established and then arranged in a randomized block design with three replications. Three days prior to application of growth retardants, plots were mowed at a cutting height of 5 cm and clippings removed. On May 11, 1983 mefluidide and EL-500 were applied at label rates of 0.42 kg/ha and 1.12 kg/ha respectively, using a CO_2 backpack sprayer at 3.44×10^5 PA (50 psi). Clippings were collected weekly from half of each treated plot and controls from a centrally located section measuring .47 m x 1.0 m using a reel type mower with attached collection bag. Samples were dried in a forced draft oven at 70 C for 5 days and then weighed. The other half of the plots remained unmowed throughout the study. Approximately 5 weeks after growth retardant application, plugs 12 cm in diameter were removed from both the mowed and unmowed portion of each plot to determine the percent total nonstructural carbohydrate (%TNC) content, total nitrogen, and the effects of mowing and not mowing on the %TNC content of turfgrass. Shoots were cut from plugs at soil level to include crown tissue. Samples were then dried at 70 C for 5 days, ground through a 40-mesh screen in a Wiley mill, and stored in air-tight bottles. The %TNC content per 50 mg sample was determined using methods outlined by Westhafer (35). The micro-Kjeldahl procedure was used to determine the total nitrogen levels (3).

Half the number of May treated plots were treated a second time at the same rates on June 16 to evaluate the effect of repeated application. Growth retardants were also applied on that date to previously untreated plots to evaluate the effect of time of application (Table 1). Collection and analysis of samples was conducted as outlined earlier.

Due to crabgrass infestation of the established plots, an adjacent location for the fall treatment was established.

As with the earlier study, plots measuring 1.5 m x 3.0 m were arranged in a randomized block design with three replications. Growth retardants were applied in early September exactly as in the previous spring to determine whether seasonal treatment affected turf quality, growth, and %TNC, which in untreated turf, usually increases in the fall in response to cooler temperatures and shorter daylengths (12,19,39). Collection and analysis of September samples was conducted as previously discussed. October application and collection was not possible due to the onset of rainy weather conditions which prevented the proper application of growth retardants (41). Later application was not feasible since turf would have responded to the lower temperatures encountered in late fall by growth cessation to achieve a maximum level of hardiness (1).

Turf quality was evaluated twice by visual observation over each 5 and 10 week period after PGR application, and the average of the 2 ratings per period reported. A quality rating system of 1 through 9, based on turf color, density, uniformity, and injury was used. A rating of 8 or above represented a green, lush, uniform turf; a score of 7 to 8, good quality; 5 to 6, fair quality; and 1 to 5 a poor quality turf. A rating below 6 indicated unacceptable turf quality due to leaf chlorosis, turf thinning, or a combination of these symptoms. To assess long term effects of growth retardants on turfgrass quality and vigor, plots were also visually rated once the following spring (1984).

TABLE 1

SCHEDULE FOR CHEMICALLY TREATED PLOTS AND CONTROLS.

Treatment Time	May	June	Sept
1	May 11	---	---
2	May 11	June 16	---
3	---	June 16	---
4	---	---	Sept 13

Growth Chamber Studies

In the greenhouse, styrofoam cups 8.9 cm in diameter, each having 4 drainage holes, were filled with a potting mixture of sand:loam:peat (2:2:1 v/v). Red fescue 'Pennfine' was seeded at a rate of 426 mg seed/cup. During the 10 week establishment period, turf was fertilized weekly with half-strength Hoagland's solution (13), with cups being randomly repositioned. After the establishment period, turf was clipped to a 5 cm height 1 day prior to growth retardant treatment. Mefluidide was applied at a rate of 0.42 kg/ha to 24 cups. Treated cups and controls (3 replications of each) were then moved to separate growth chambers programmed for a 12 hour light/dark diurnal cycle. Light intensity was 65 uEm^{-2} s^{-1} of fluorescent and incandescent light. Temperature regime for half the number of cups was 21 C during the light period and 13 C during the dark cycle to serve as a check, and 35 C/24 C (light/dark) for inducing temperature stress in the remaining cups. Turf was watered twice weekly with 100 ml of water with cups randomly repositioned, and once per week with half-strength Hoagland's solution (13). Total shoot growth was collected from 3 cups of each treatment including 3 controls every week for 5 weeks by excising plants at the soil level to include crown tissue. At this time turf quality ratings were taken to evaluate turf injury using the rating system described for the field studies. The average of the 5 quality ratings taken over the 5 week period was statistically analyzed and reported. Samples were then dried and stored as previously mentioned. The effects of growth retardants used in combination with temperature stress on the soluble components (glucose, fructose, and sucrose) and the insoluble component, fructosan, were assessed per 50 mg sample using methods described by Westhafer (35). These analyses accounted for reducing, nonreducing, and reserve carbohydrate fluctuations. Total nitrogen was determined using the micro-Kjeldahl procedure (3).

The above procedure was repeated for plants treated with EL-500 applied at a rate of 1.12 kg/ha, and controls.

CHAPTER IV

RESULTS

FIELD STUDY

Growth.

Significantly lower dry weights of weekly clippings confirmed the ability of mefluidide and EL-500 to retard grass growth at each application date (Table 1), as compared to controls (Table 10,11,12,13 and Figure 1,2,3,4). May PGR treatment resulted in a 79% and 49% reduction in shoot dry weights for mefluidide and EL-500 treated turf respectively, by two weeks after application (Table 10, Figure 1). June treatment indicated growth reduction of 49% for mefluidide and 27% for EL-500 two weeks after application (Table 11, Figure 2), while May plus June treatment also showed a 49% reduction for mefluidide, but 56% for EL-500 (Table 12, Figure 3). By two weeks after September treatment, mefluidide had reduced growth by 88%, and EL-500 by 66% (Table 13, Figure 4). Over each five week period after chemical application, mefluidide suppressed growth more effectively than did EL-500, with the exception of May application period, where dry weights were approximately equal. Both were still maintaining significant shoot growth reduction at the end of each five week period after application.

Turfgrass Quality.

Comparison of chemically treated plants in the field to controls indicated a noticeable decrease in turf quality of treated plants over a ten week period following PGR application, although in general, this difference was not statistically significant possibly because the average of the ratings over each five week period was analyzed, instead of ratings taken every two weeks (Tables 3-8). There may also have been inconsistencies in the quality rating procedure.

May application: Mefluidide treated turf was showing signs of leaf injury by week two, and had quality ratings below six, or unacceptable, by week four. EL-500 treated turf showed signs of injury by two weeks after treatment and also had quality ratings below six by week four, but the injury was not as pronounced as with mefluidide. The injurious effects of both chemicals had begun to diminish by week seven, with quality ratings of six or higher by six to ten weeks after treatment (Table 2,3). Throughout the entire ten week period controls maintained ratings above six. Quality ratings taken the following spring to evaluate longer term turf recovery and vigor were above six and comparable for all plots (Table 2,3).

June application: Mefluidide treated turf showed injury by week two, with quality ratings of six or below during weeks one to five and ratings below four over weeks six to ten, which was comparable to controls (Table 4,5). Although some EL-500 treated plots showed objectionable injury by week two, turf ratings were comparable to or better than controls due to a green-up response in other EL-500 treated plots, with average ratings over the five week period of six or above (Table 4,5). During weeks six to ten, quality ratings for EL-500 treated plots were higher than for controls. Ratings taken the following spring showed EL-500 treated turf to be of equal or higher quality as compared to controls, whereas mefluidide treated plots had lower ratings than controls (Table 4,5).

May plus June application: There were no significant differences between quality ratings of treated plots and controls (Table 6,7), but quality ratings for May plus June PGR application period were lower than those for plots treated only in June. Turf recovery rate, as compared to controls, was difficult to determine after June and May plus June applications because all plots were subject to extreme temperature stress, resulting in turf discoloration and summer dormancy from mid July through August.

September application: Quality ratings for mefluidide treated plots were slightly lower than for controls and EL-

500 treated plots, with injury visible by week two (Table 8). However, this injury was less severe than that for all other application dates at two weeks after treatment, with ratings of six or above and turf showing a slight green-up response (Figure 5,6). Some EL-500 treated plots also had slight injury by week two, but most were exhibiting a stronger green-up response in the fall than at other application dates, which peaked by week three (Figure 7). Turf quality declined shortly thereafter, with signs of browning and thinning by week four. At this time mefluidide treated plots were regaining color. All plots received quality ratings of seven the following spring, which were higher than for plots treated at other application dates. Mowing appeared to have little effect on turf quality compared to no mowing, during the summer, fall or following spring.

<u>Nonstructural carbohydrate and nitrogen levels.</u>

Five weeks after May application: Neither mefluidide nor EL-500 seemed to affect soluble and insoluble carbohydrate levels of unmowed or mowed turf with respect to controls. Total nitrogen levels were also consistent among treated and nontreated plots (Table 14). The same results were observed at ten after May application (Table 15).

Five weeks after June application: Neither mefluidide nor EL-500 appeared to significantly affect soluble nor insoluble carbohydrate levels of unmowed turf as compared to controls (Table 16). However, mefluidide treatment did result in significantly lower soluble carbohydrate levels in mowed turf, while insoluble carbohydrates were comparable to controls. Chemical treatments had no significant effects on nitrogen levels. At ten weeks after June treatment there were no significant differences concerning sugar or nitrogen levels. However, soluble sugars seemed to be slightly lower for treated plots than for controls (Table 17).

Five weeks after May and June application: Chemical treatments had no significant effects on carbohydrate levels of mowed or unmowed turf, or nitrogen levels as compared to controls (Table 18). At ten weeks after May and June treatment soluble sugars were significantly lower for unmowed treated plots than for controls, while insoluble sugar and nitrogen levels were comparable to controls (Table 19). There were no significant differences among mowed treated plots and controls for soluble and insoluble sugars or nitrogen.

Five weeks after September application: Soluble carbohydrate and nitrogen levels were not significantly different for treated mowed and unmowed plots than controls (Table 20). However, in treated unmowed plots, insoluble carbohydrate levels were significantly lower than for controls, while mowed plots had levels comparable to controls. Because this study was terminated in late October due to cold, rainy weather conditions, data at ten weeks after September PGR application were not collected.

Soluble and insoluble carbohydrate levels were higher in the fall for both unmowed and mowed plots. Except for May application, unmowed plots had higher soluble carbohydrate levels than mowed plots. Soluble carbohydrate levels were slightly lower for unmowed mefluidide treated plots than for controls at all application dates. Unmowed EL-500 treated plots had soluble carbohydrate levels that were equal to or higher than controls for May , June and May plus June applications, while mowed plots had higher levels than controls for May and September.

GROWTH CHAMBER STUDY

Although dry weights of treated turf and controls were not measured, PGR application did visibly reduce shoot growth.

Quality Ratings.

The average of low temperature quality ratings for mefluidide treated plants were approximately equal to controls, with no visible green-up response by treated turf (Table 9, Figure 8). EL-500 treated plants had average quality ratings equal to or higher than controls at both low and high temperature, although not significantly different

(Table 9, Figure 9,10). No green-up response was observed for treated plants at low temperature, but was noticible in several treated plants at week one and two under high temperature conditions.

Nonstructural carbohydrate and nitrogen levels.
Soluble sugars levels at low temperature were significantly higher for mefluidide treated plants than controls at weeks one, two, and three, while insoluble sugar levels were comparable to controls (Table 21, Figure 11). Total nitrogen was also significantly higher for treated plants at week two. Due to accidental destruction of samples, data at high temperature were not available for analysis.

At all weeks soluble sugar levels for EL-500 treated plants at low temperature were higher than for controls, although not significantly so (Table 22 and Figure 12). By week two soluble sugars had declined sharply and remained constant through week four, as did controls.

Insoluble sugars were significantly higher for controls at week one, but comparable to treated plants thereafter. Total nitrogen for treated and untreated turf was approximately equal.

At high temperature soluble sugars were significantly higher for controls than EL-500 treated plants at week one, and comparable for weeks two through four (Table 23, Figure 13). Insoluble sugar levels were depleted in both treated plants and control by week one, and nitrogen levels comparable at all weeks.

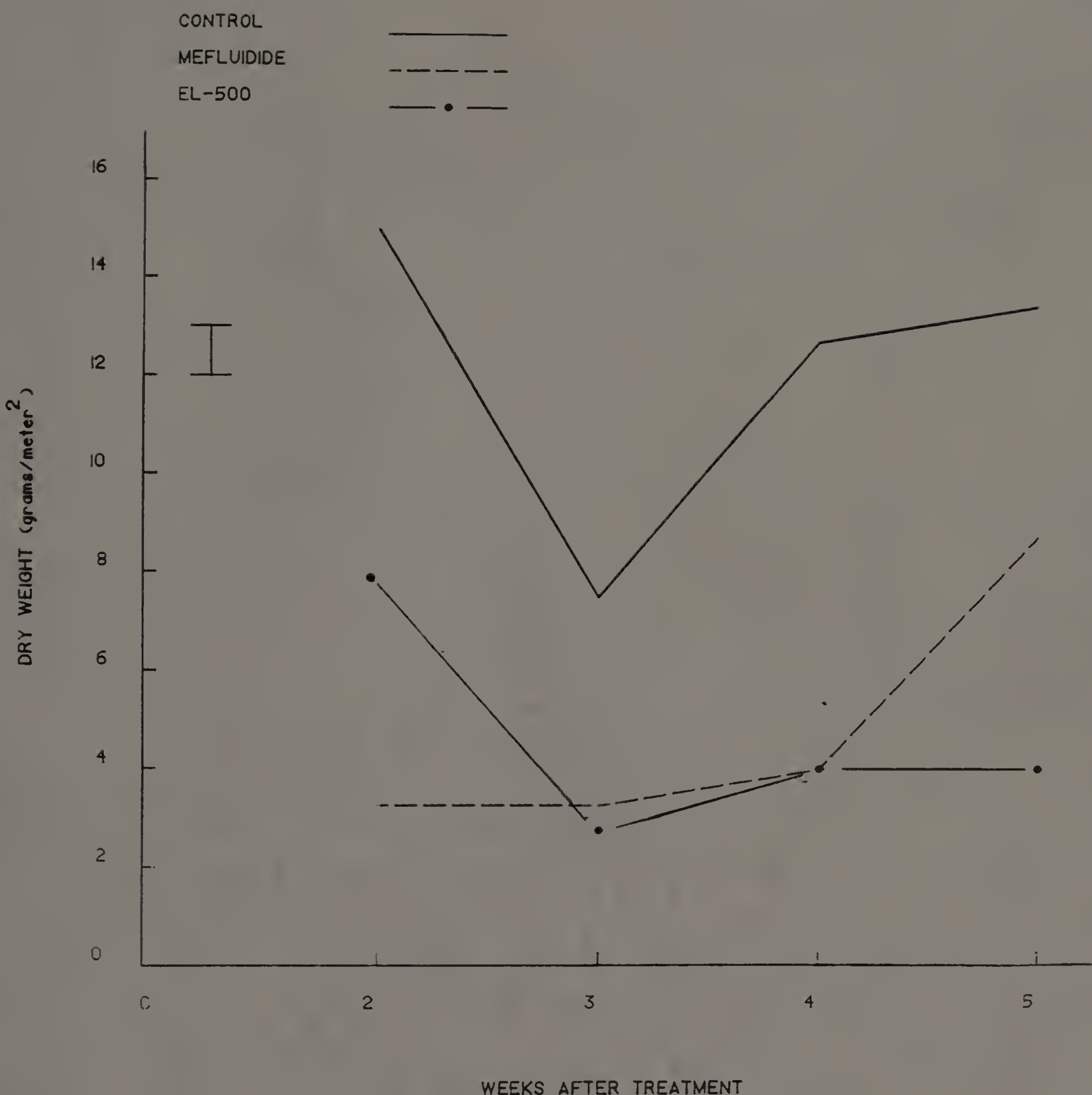

FIGURE 1

WEEKLY DRY WEIGHTS FROM MAY TREATED PLOTS.

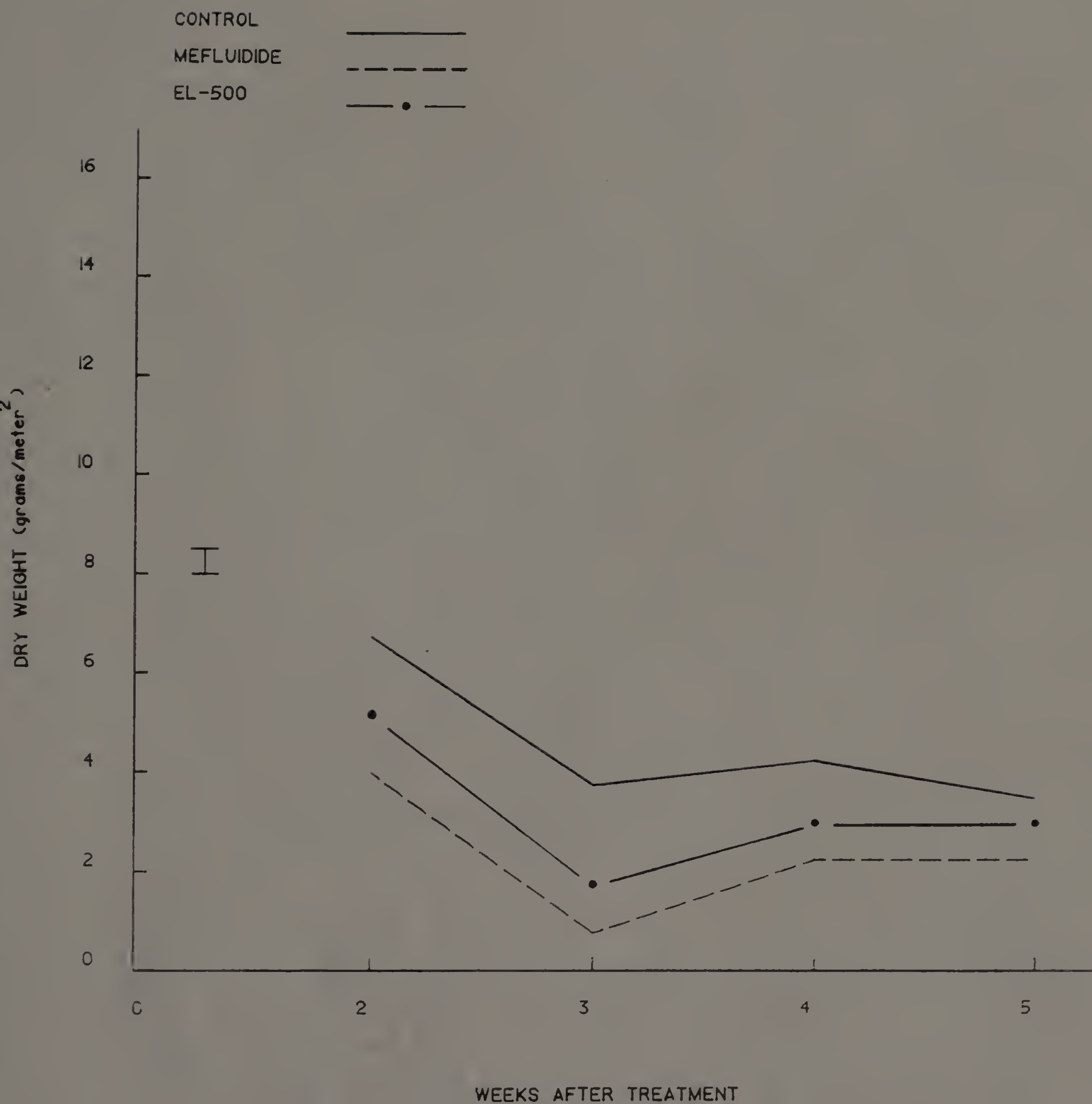

FIGURE 2

WEEKLY DRY WEIGHTS FROM JUNE TREATED PLOTS.

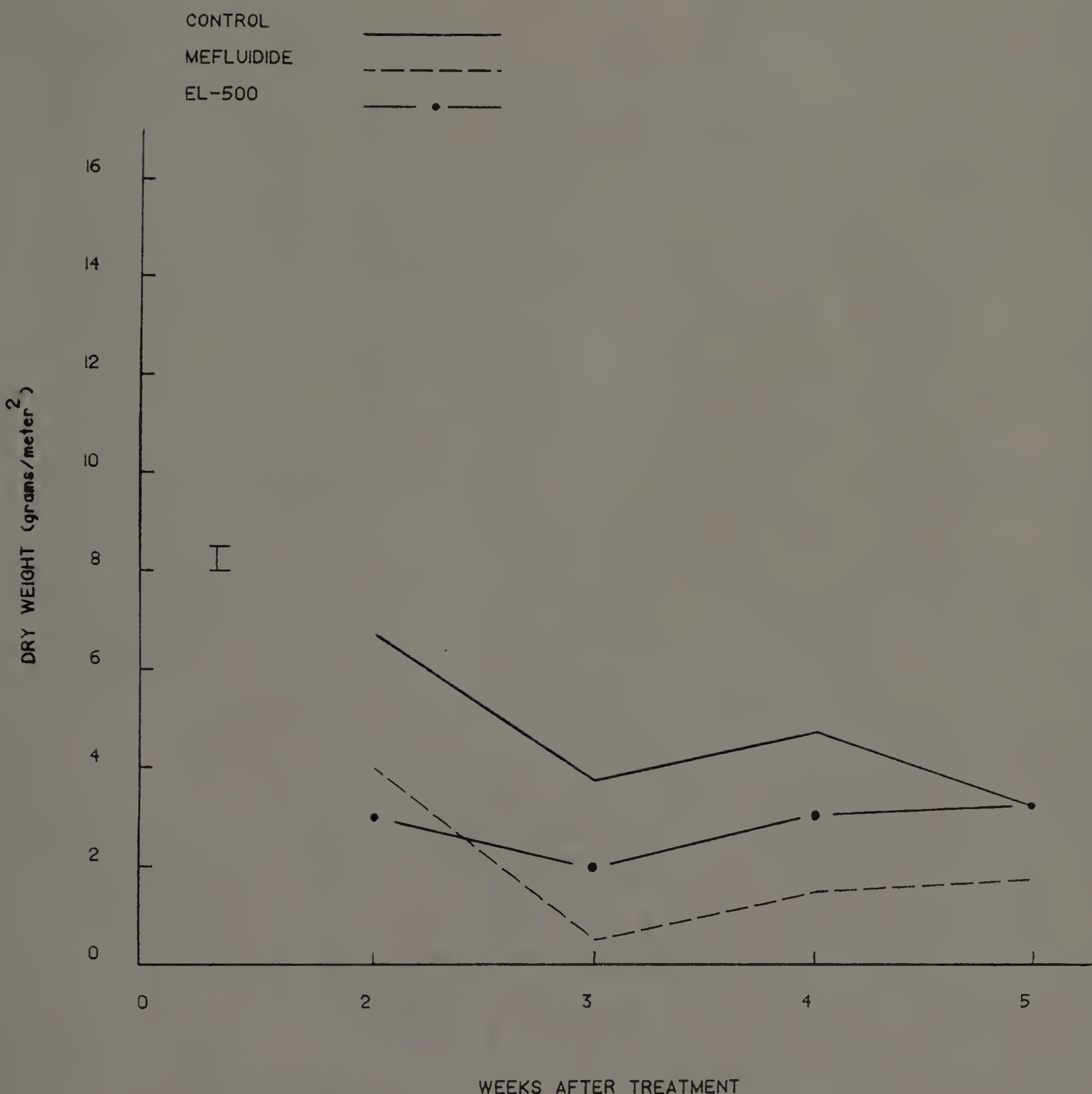

FIGURE 3

WEEKLY DRY WEIGHTS FROM MAY PLUS JUNE TREATED PLOTS.

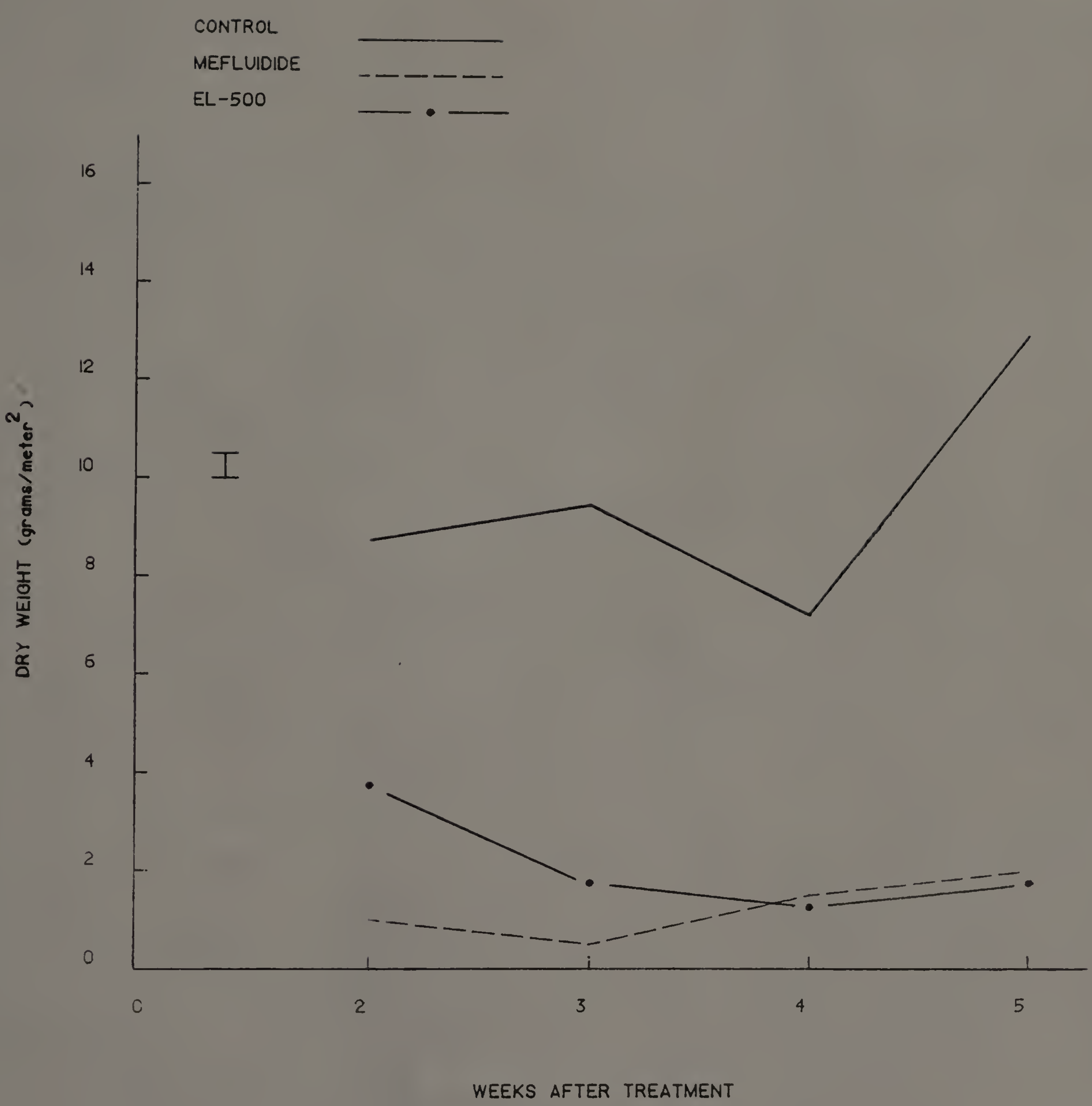

FIGURE 4

WEEKLY DRY WEIGHTS FROM SEPTEMBER TREATED PLOTS.

TABLE 2

QUALITY RATINGS OF UNMOWED TURF OVER 5 & 10 WEEK PERIOD AFTER MAY, 1983 TREATMENT AND FOLLOWING SPRING, 1984.

Treatment	Period After Treatment (weeks)		
	1-5	6-10	Following Spring
Mefluidide	5.7	6.1	6.5
EL-500	6.0	6.1	6.3
Control	6.1	6.4	6.0
$S\bar{x}$	0.33	0.36	0.67

Quality Rating Scale:

1-5 = poor
6 = fair
7 = good
8-9 = excellent

Comparisons:

Mefluidide vs EL-500	ns	ns	ns
Chemicals vs Control	ns	ns	ns

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 3

QUALITY RATINGS OF MOWED TURF 10 WEEKS AFTER MAY, 1983 TREATMENT AND FOLLOWING SPRING, 1984.

Treatment	Period After Treatment (weeks) 6-10	Following Spring
Mefluidide	6.5	6.5
EL-500	6.3	6.3
Control	6.5	6.0
$S\bar{x}$	0.23	0.67

Quality Rating Scale:

1-5 = poor
6 = fair
7 = good
8-9 = excellent

Comparisons:

Mefluidide vs EL-500	ns	ns
Chemicals vs Control	ns	ns

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 4

QUALITY RATINGS OF UNMOWED TURF OVER 5 & 10 WEEK PERIOD AFTER JUNE, 1983 TREATMENT, AND FOLLOWING SPRING, 1984.

Treatment	Period After Treatment (weeks)		
	1-5	6-10	Following Spring
Mefluidide	5.9	3.3	4.7
EL-500	6.6	5.2	6.7
Control	6.4	3.2	6.0
$S\bar{x}$	0.34	0.80	0.59

Quality Rating Scale:

1-5 = poor
6 = fair
7 = good
8-9 = excellent

Comparisons:

Mefluidide vs EL-500	ns	ns	ns
Chemicals vs Control	ns	ns	ns

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 5

QUALITY RATINGS OF MOWED TURF OVER 5 & 10 WEEK PERIOD AFTER JUNE, 1983 TREATMENT, AND FOLLOWING SPRING, 1984.

Treatment	Period After Treatment (weeks) 1-5	6-10	Following Spring
Mefluidide	5.0	3.5	4.7
EL-500	5.9	6.0	6.7
Control	6.3	4.0	6.0
$S\bar{x}$	0.31	0.24	0.59

Quality Rating Scale:

1-5 = poor
6 = fair
7 = good
8-9 = excellent

Comparisons:

	1-5	6-10	Following Spring
Mefluidide vs EL-500	ns	*	ns
Chemicals vs Control	ns	*	ns

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 6

QUALITY RATINGS OF UNMOWED TURF OVER 5 & 10 WEEK PERIOD AFTER MAY PLUS JUNE, 1983 TREATMENT, AND FOLLOWING SPRING, 1984.

Treatment	Period After Treatment (weeks) 1-5	6-10	Following Spring
Mefluidide	5.9	2.5	5.0
EL-500	6.4	3.6	6.5
Control	6.5	3.2	6.0
$S\bar{x}$	0.29	0.58	0.60

Quality Rating Scale:
1-5 = poor
6 = fair
7 = good
8-9 = excellent

Comparisons:

Mefluidide vs EL-500	ns	ns	ns
Chemicals vs Control	ns	ns	ns

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 7

QUALITY RATINGS OF MOWED TURF OVER 5 & 10 WEEK PERIOD AFTER MAY + JUNE, 1983 TREATMENT, AND FOLLOWING SPRING, 1984.

Treatment	Period After Treatment (weeks)		
	1-5	6-10	Following Spring
Mefluidide	4.5	3.2	5.0
EL-500	5.9	4.7	6.5
Control	6.2	4.2	6.0
$S\bar{x}$	0.39	0.52	0.60

Quality Rating Scale:
1-5 = poor
6 = fair
7 = good
8-9 = excellent

Comparisons:

Mefluidide vs EL-500	ns	ns	ns
Chemicals vs Control	ns	ns	ns

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 8

QUALITY RATINGS OF TURF OVER 5 WEEK PERIOD AFTER SEPTEMBER, 1983 TREATMENT AND FOLLOWING SPRING, 1984. #

Treatment	Period After Treatment (weeks) 1-5	Following Spring
Mefluidide	6.8	7.0
EL-500	7.2	7.0
Control	7.8	7.0
$S\bar{x}$	0.18	0.00

Quality Rating Scale:

1-5 = poor
6 = fair
7 = good
8-9 = excellent

Comparisons:

Comparison	1-5	Following Spring
Mefluidide vs EL-500	*	ns
Chemicals vs Control	*	ns

#: Quality ratings not different between mowed and unmowed plots.
Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

FIGURE 5

TURF QUALITY OF MEFLUIDIDE (left), EL-500 (center), AND CONTROL (right) PLOTS AT THREE WEEKS AFTER SEPTEMBER TREATMENT.

FIGURE 6

COMPARISON OF MEFLUIDIDE (left), AND EL-500 (right), TREATED PLOTS AT THREE WEEKS AFTER SEPTEMBER TREATMENT.

FIGURE 7

GREEN-UP RESPONSE OF EL-500 TREATED TURF (left) AS COMPARED TO CONTROL (right) AT THREE WEEKS AFTER SEPTEMBER TREATMENT.

TABLE 9

QUALITY RATINGS FOR TREATED TURF AND CONTROLS AT LOW AND HIGH TEMPERATURE (21C/13C,34C/25C, LIGHT/DARK), OVER FIVE WEEK PERIOD.#

TREATMENT	WEEKS IN GROWTH CHAMBER					
	0	1	2	3	4	$\bar{x}$
Mef. Low T.	8.5	7.8	7.7	6.7	7.0	7.5
Cont. Low T.	8.5	7.8	7.8	7.3	7.0	7.7
$S\bar{x}$						0.11
EL-500 Low T.	8.5	7.2	7.0	7.7	6.7	7.3
Cont. Low T.	8.5	7.2	6.8	6.8	6.8	7.2
EL-500 High	8.5	6.8	6.3	5.3	4.3	6.2
Cont. High	8.5	6.7	6.2	5.5	4.7	6.3
$S\bar{x}$						0.15

Quality Rating Scale:

1-5 = poor
6 = fair
7 = good
8-9 = excellent

Comparisons:	
Mef. vs Cont.	ns
EL-500 vs Cont.	ns
Low T. vs High T.(EL-500)	**
Low T. vs High T.(Cont.)	**

#: Anova performed on means only.
Ns, *, **: No significance, significance at the 0.05 and 0.01 levels, respectively.

FIGURE 8

QUALITY OF MEFLUIDIDE TREATED TURF (top), AND CONTROLS (bottom), AT LOW TEMPERATURE (21/13C, light/dark).

FIGURE 9

QUALITY OF EL-500 TREATED TURF (top), AND CONTROLS, (bottom), AT LOW TEMPERATURE (21C/13C, light/dark).

FIGURE 10

QUALITY OF EL-500 TREATED TURF (top), AND CONTROLS (bottom), AT HIGH TEMPERATURE (34C/25C, light/dark).

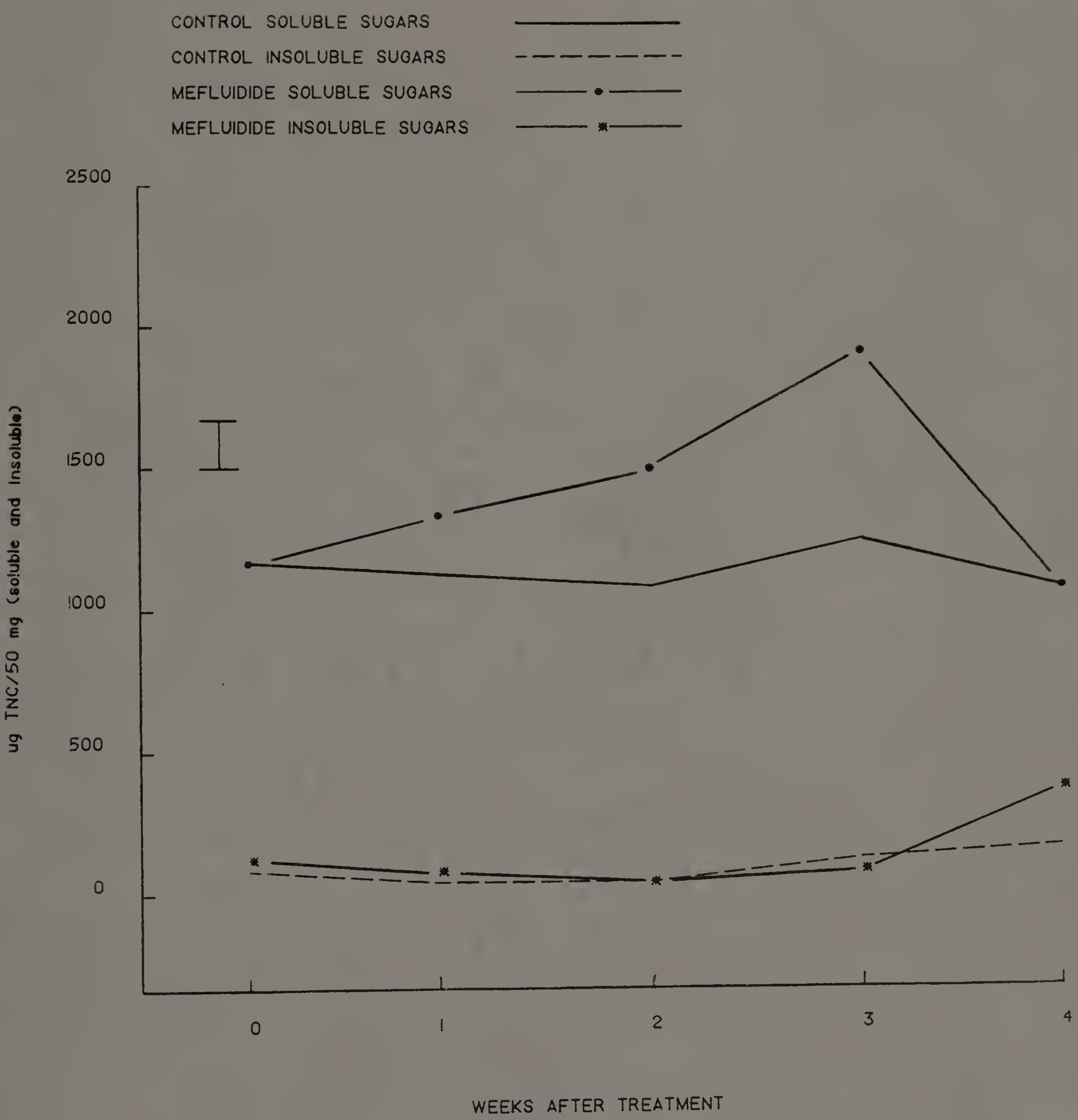

FIGURE II

WEEKLY TNC LEVELS (SOLUBLE AND INSOLUBLE) OF MEFLUIDIDE TREATED TURF AT LOW TEMPERATURE (21C/13C, LIGHT/DARK).

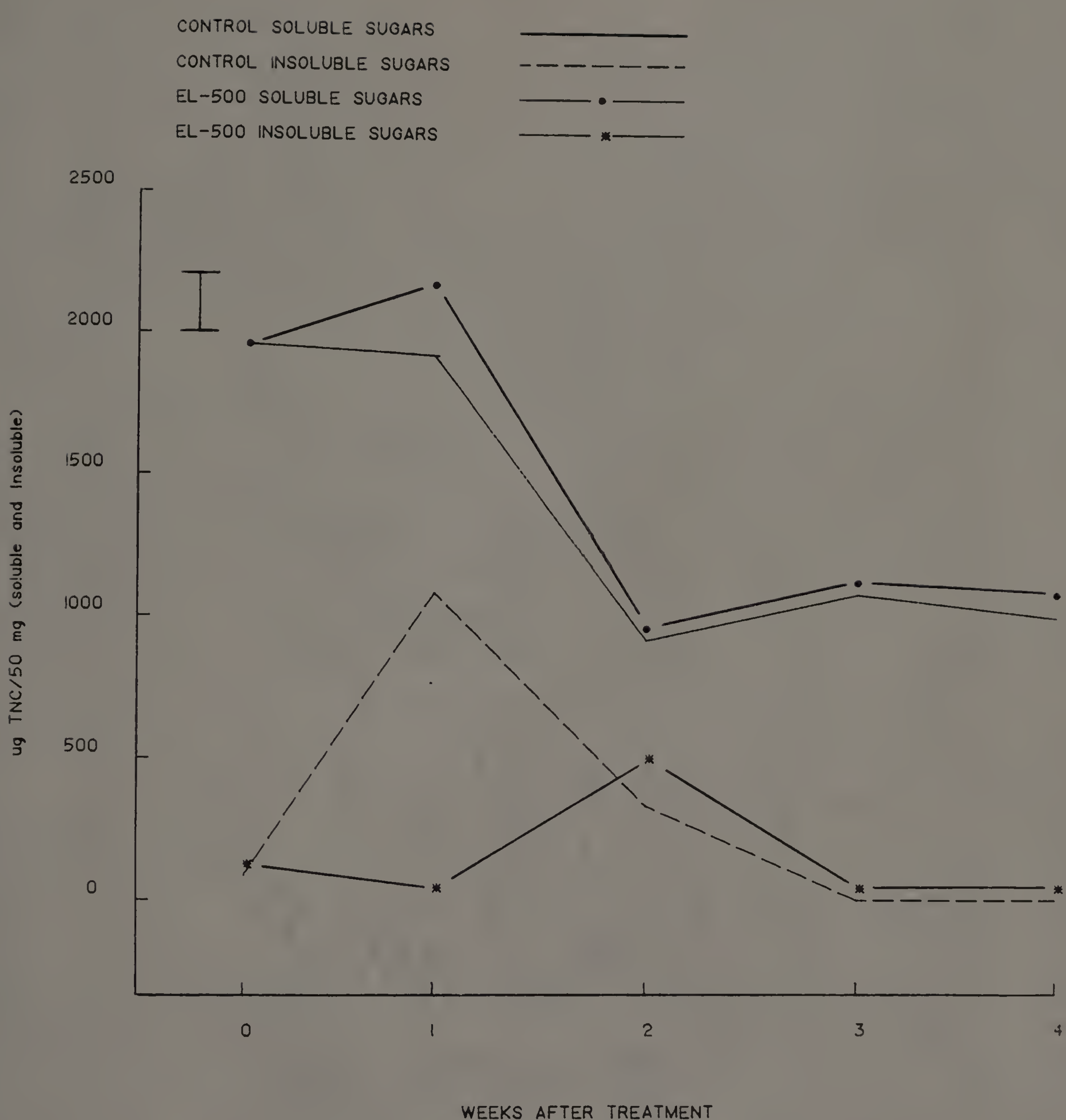

FIGURE 12

WEEKLY TNC LEVELS (SOLUBLE AND INSOLUBLE) OF EL-500 TREATED TURF AT LOW TEMPERATURE (21C/13C, LIGHT/DARK).

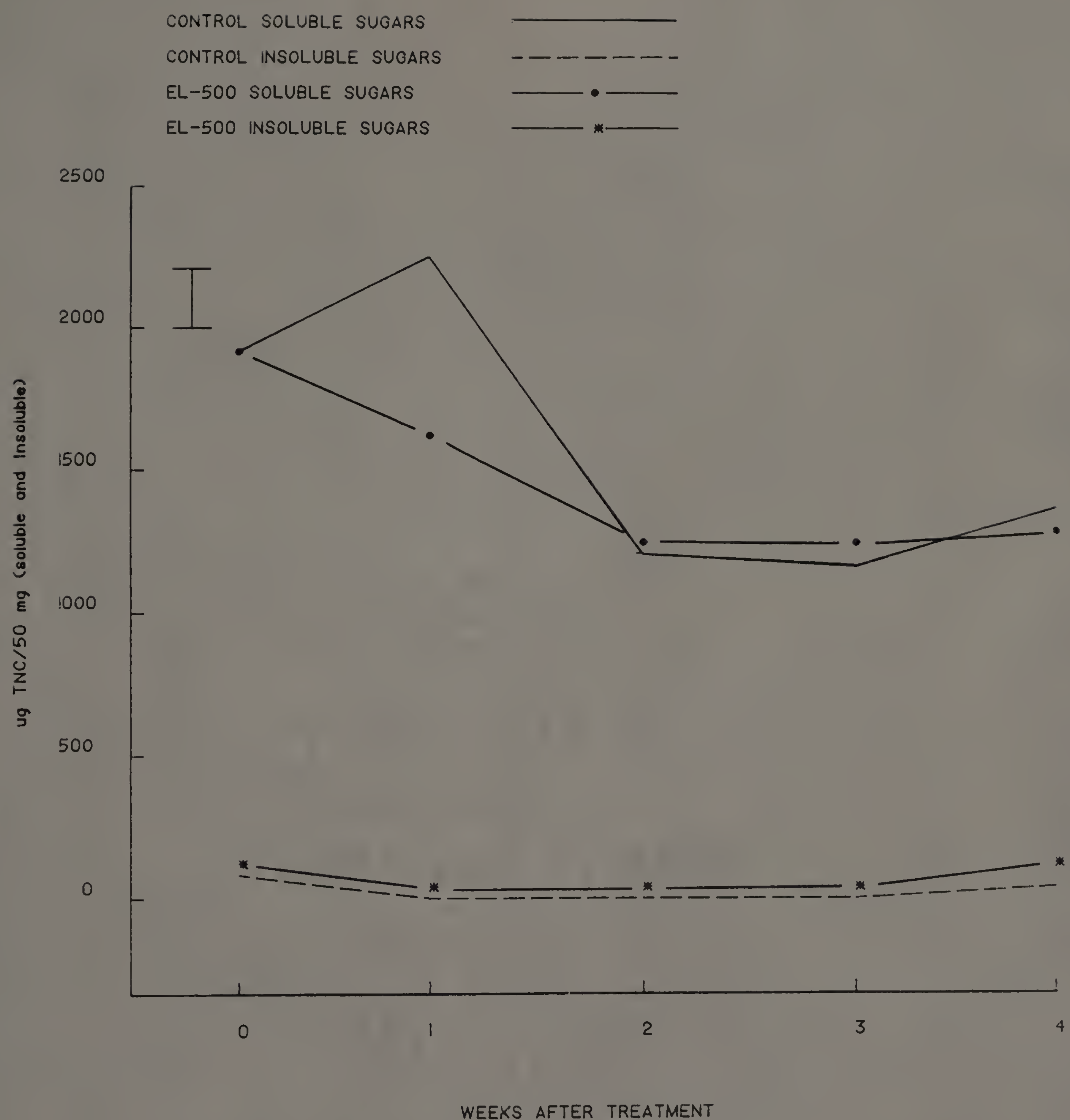

FIGURE 13

WEEKLY TNC LEVELS (SOLUBLE AND INSOLUBLE) OF EL-500 TREATED TURF AT HIGH TEMPERATURE (35C/24C, LIGHT/DARK).

CHAPTER V

DISCUSSION AND CONCLUSIONS

Growth. It is apparent the the PGR's used in this study have the ability to retard grass growth. Turf treated with mefluidide and EL-500 resulted in significant reduction of shoot dry weights under field conditions at all application dates. Shoot height reduction was also noticible for treated turf in the growth chamber study. These observations indicate the potential of mefluidide and EL-500 to reduce turf maintenance costs. However, a phytotoxic response associated with the application of the chemicals, which worsened under temperature stress, resulted in unaccpetable quality for intensively managed turf.

There were differences between mefluidide and EL-500 as to the time plants responded to chemical treatment. Mefluidide reduced grass growth more quickly than did EL-500 after May and September application dates. The quicker growth reduction may be due to foliar absorption of mefluidide, as opposed to root absorption of EL-500. Turf responded more slowly to mefluidide than to EL-500 after June and May plus June application. Possibly increased temperatures and droughty conditions interfered with foliar absorption and translocation of mefluidide (41).

Carbohydrate Levels. At five weeks after May, June and May plus June PGR application, there were no significant differences between treated plots and controls with respect to TNC levels. Watschke obtained comparable results by week four in a study where carbohydrate levels from turf treated with mefluidide and controls were sampled every two weeks from June to October (28). However, at two weeks after May and June PGR application, Watschke reported that carbohydrate levels of mefluidide treated plants were higher than for controls (28). Although samples from the field were analyzed for TNC only at five and ten weeks after PGR application in this study, TNC levels of growth chamber samples were determined weekly. The results for mefluidide treated plants concurred with observations by Watschke in that mefluidide treated turf at low temperature had significantly higher TNC levels than did controls by two weeks after treatment (Figure 11). These differences had diminished by four weeks after treatment. Unfortunately, comparision at high temperature was not possible due to the accidental destruction of samples for mefluidide treated turf and controls.

High temperature data for EL-500 treated turf and controls indicated depletion of carbohydrate reserves (insoluble sugars) by week one for both, (Figure 13), with soluble sugar levels significantly higher for controls. Soluble sugar levels at low temperature were higher for EL-500 treated plants at week one, and insoluble sugar levels higher at week two, than for controls. This response may be the result of less carbohydrate depletion shortly after treatment for plants treated with EL-500 or mefluidide under optimal temperature conditions. The higher carbohydrate levels also correlate with a marked green-up response shown by EL-500 treated turf, and less pronounced with mefluidide treated turf at approximately two to three weeks after PGR application. This response was most pronounced at three weeks after September PGR application (Figure 5,6,7), but field data was not collected at this time for TNC.

It was postulated that accumulated TNC resulting from growth suppression after PGR application could be used to provide growth capability during periods of temperature stress (28). At high temperature in the growth chamber study, TNC levels were depleted for both controls and treated turf by week one. The temperature was possibly extreme and the time too short before depletion to indicate whether increased carbohydrate synthesis would have occurred in treated plants, and if so, whether this accumulated TNC would have resulted in better stress endurance.

In the field, carbohydrate levels for mefluidide treated turf were lower than for controls at five weeks after June and May plus June applications when temperatures were highest. However, for EL-500 treated turf, both unmowed and mowed plots had higher carbohydrate levels than controls. Five weeks after September application, with concurrent cooler temperatures, both mefluidide and EL-500 treated turf had lower TNC levels than controls. These results seem to indicate that under temperature stress, plants treated with EL-500 appear to have slightly higher carbohydrate levels which may reflect better plant maintenance under environmental stress.

Turf quality ratings taken the following spring were also slightly higher for EL-500 treated turf than for controls at all application dates (except September, where ratings were equal), which seems to indicate better turf recovery rates. In general, following spring quality ratings were lower for turf treated with mefluidide except for plots treated in September, which had ratings equal to controls.

These studies have given evidence that turf treated with selected commercial and experimental growth retardants results in effective growth suppression, which is desirable to reduce turf maintenance costs. Under summer temperature stress encountered in the field, EL-500 treated turf appeared to sustain slightly higher carbohydrate levels which may have contributed to turf recovery and green-up rate the following spring.

Despite the excellent growth retardation caused by both chemicals, and improved recovery rates of EL-500 treated turf the following spring, their application to turf resulted in unacceptable leaf injury. The leaf injury increased in midsummer with temperature appearing to be the responsible factor. Therefore, use of these growth retardants should be limited to areas where reductions in aesthetic quality of turfgrass can be tolerated.

FOOTNOTES

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APPENDIX A

TABLE 10

WEEKLY DRY MATTER PRODUCTION OF MAY TREATED PLOTS.

Treatment	Weeks After Treatment				
	2	3	4	5	$\bar{x}$
Mef.	3.4	3.4	4.3	9.1	5.1
EL-500	8.1	3.0	4.3	4.3	4.9
Control	16.0	8.1	13.4	14.3	12.9

$S\bar{x}$ 0.81

Comparisons:

Mef. vs EL-500	*	ns	ns	*
Chem vs Control	**	**	**	**

Means $\pm$ s.e. expressed in grams/meter2.
Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

ANOVA

Source	DF	Sum Sq	Mean Sq	F-Value	Prob(F)
Mean	1	463.68	463.68	237.44	
Trt	2	110.55	55.28	28.30	0.0000
Date	3	26.33	8.78	4.49	0.0132
Blk	2	3.76	1.88	0.96	0.3970
Trt,Date	6	22.64	3.77	1.93	0.1202
Residual	22	42.96	1.95	1.00	

TABLE 11

WEEKLY DRY MATTER PRODUCTION OF JUNE TREATED PLOTS.

Treatment	Weeks After Treatment				
	2	3	4	5	$\bar{x}$
Mef.	4.3	0.6	2.6	2.3	2.5
EL-500	5.3	1.9	3.2	3.2	3.4
Control	7.2	3.8	4.5	3.6	4.8
$S\bar{x}$ 0.29					
Comparisons:					
Mef. vs EL-500	*	*	ns	*	
Chem vs Control	**	**	**	**	

Means $\pm$ s.e. expressed in grams/meter2.
Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

ANOVA

Source	DF	Sum Sq	Mean Sq	F-Value	Prob(F)
Mean	1	100.67	100.67	382.43	
Trt	2	7.01	3.50	13.31	0.0002
Date	3	12.86	4.29	16.28	0.0000
Blk	2	0.38	0.19	0.71	0.5010
Trt,Date	6	0.72	0.12	0.46	0.8323
Residual	22	5.79	0.26	1.00	

TABLE 12

WEEKLY DRY MATTER PRODUCTION OF MAY + JUNE TREATED PLOTS.

Treatment	Weeks After Treatment				
	2	3	4	5	$\bar{x}$
Mef.	4.3	0.6	1.5	1.7	2.0
EL-500	3.2	1.7	3.4	3.0	2.8
Control	7.2	3.8	4.5	3.2	4.7
$S\bar{x}$ 0.36					
Comparisons:					
Mef. vs EL-500	*	*	*	*	
Chem vs Control	**	**	**	**	

Means $\pm$ s.e. expressed in grams/meter2.
Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

ANOVA

Source	DF	Sum Sq	Mean Sq	F-Value	Prob(F)
Mean	1	81.00	81.00	202.85	
Trt	2	10.75	5.37	13.45	0.0002
Date	3	8.95	2.98	7.47	0.0013
Blk	2	0.02	0.01	0.02	0.9814
Trt,Date	6	2.55	0.42	1.06	0.4139
Residual	22	8.79	0.39	1.00	

TABLE 13

WEEKLY DRY MATTER PRODUCTION OF SEPTEMBER TREATED PLOTS.

Treatment	Weeks After Treatment				
	2	3	4	5	$\bar{x}$
Mef.	1.1	0.6	1.7	2.1	1.4
EL-500	4.0	1.9	1.5	1.9	2.3
Control	9.1	10.0	7.7	13.8	10.2
$S\bar{x}$ 0.55					
Comparisons:					
Mef. vs El-500	*	*	ns	ns	
Chem vs Control	**	**	**	**	

Means $\pm$ s.e. expressed in grams/meter2.
Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

ANOVA

Source	DF	Sum Sq	Mean Sq	F-Value	Prob(F)
Mean	1	277.56	277.56	308.16	
Trt	2	159.02	79.51	88.28	0.0000
Date	4	23.39	5.85	6.49	0.0008
Blk	2	4.84	2.42	2.69	0.0856
Trt,Date	8	18.60	2.32	2.58	0.0301
Residual	28	25.22	0.90	1.00	

TABLE 14

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN, 5 WEEKS AFTER MAY TREATMENT.

Treatment	% Sol. TNC	% Insol. TNC	% Total N	Corr. Coef.
Mefluidide				
unmowed	4.5	0.4	0.5	0.3
mowed	5.4	0.5	0.5	0.8
EL-500				
unmowed	4.7	0.3	0.6	0.0
mowed	4.9	0.3	0.6	0.8
Control				
unmowed	4.7	0.5	0.5	-0.9
mowed	4.4	1.0	0.5	0.5
Comparisons:				
Unmowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	
Mowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 15

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN, 10 WEEKS AFTER MAY TREATMENT.

Treatment	% Sol. TNC	% Insol. TNC	% Total N	Corr. Coef.
Mefluidide				
unmowed	5.8	0.2	0.6	0.9
mowed	5.0	0.4	0.6	0.9
EL-500				
unmowed	5.6	0.5	0.6	-0.6
mowed	5.4	0.1	0.6	0.6
Control				
unmowed	6.3	0.5	0.5	0.9
mowed	5.0	0.1	0.5	0.3
Comparisons:				
Unmowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	
Mowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR UNMOWED PLOTS 5 WEEKS AFTER MAY TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	56967272	56967272	267.29	
Trt	2	95584	47792	0.22	0.8085
Block	2	221660	110830	0.52	0.6299
Resid	4	852520	213130	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR UNMOWED PLOTS 10 WEEKS AFTER MAY TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	90611361	90611361	773.81	
Trt	2	331609	165804	1.42	0.3428
Block	2	232433	116216	0.99	0.4467
Resid	4	468391	117098	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR MOWED PLOTS 5 WEEKS AFTER MAY TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	64416676	64416676	371.11	
Trt	2	375061	187530	1.08	0.4216
Block	2	822241	411120	2.37	0.2096
Resid	4	694321	173580	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR MOWED PLOTS 10 WEEKS AFTER MAY TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	69377794	69377794	624.69	
Trt	2	62662	31331	0.28	0.7680
Block	2	822241	411120	2.37	0.1604
Resid	4	444235	111059	1.00	

TABLE 16

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN, 5 WEEKS AFTER JUNE TREATMENT.

Treatment	% Sol. TNC	% Insol. TNC	% Total N	Corr. Coef.
Mefluidide				
unmowed	5.6	0.2	0.5	0.0
mowed	4.1	0.0	0.6	-0.9
EL-500				
unmowed	7.0	0.3	0.6	-0.9
mowed	4.5	0.2	0.5	-0.9
Control				
unmowed	6.3	0.6	0.5	0.9
mowed	5.3	0.1	0.5	0.3
Comparisons:				
Unmowed:				
Mef vs Control	ns	ns	ns	
Chem vs Control	ns	ns	ns	
Mowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	*	ns	ns	

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 17

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN, 10 WEEKS AFTER JUNE TREATMENT.

Treatment	% Sol. TNC	% Insol. TNC	% Total N	Corr. Coef.
Mefluidide				
unmowed	1.0	0.0	0.6	0.6
mowed	3.9	0.0	0.6	-0.2
EL-500				
unmowed	4.4	0.0	0.6	-0.9
mowed	3.9	0.0	0.6	0.9
Control				
unmowed	5.1	0.0	0.5	-0.6
mowed	4.8	0.0	0.5	0.5
Comparisons:				
Unmowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	
Mowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR UNMOWED PLOTS 5 WEEKS AFTER JUNE TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	100600900	100600900	555.49	
Trt	2	922766	461383	2.55	0.1934
Block	2	265333	132666	0.73	0.5357
Resid	4	724417	181104	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR UNMOWED PLOTS 10 WEEKS AFTER JUNE TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	39992976	39992976	196.71	
Trt	2	1342467	671233	3.30	0.1423
Block	2	168217	84108	0.41	0.6866
Resid	4	813221	203305	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR MOWED PLOTS 5 WEEKS AFTER JUNE TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	50927253	50927253	1021.22	
Trt	2	641355	320677	6.43	0.0543
Block	2	596275	298137	5.97	0.0628
Resid	4	199476	49869	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR MOWED PLOTS 10 WEEKS AFTER JUNE TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	35573272	35573272	360.10	
Trt	2	21654	10827	0.11	0.8988
Block	2	635760	317880	3.22	0.1469
Resid	4	395151	98788	1.00	

TABLE 18

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN, 5 WEEKS AFTER MAY PLUS JUNE TREATMENT.

Treatment	% Sol. TNC	% Insol. TNC	% Total N	Corr. Coef.
Mefluidide				
unmowed	5.1	0.0	0.6	0.6
mowed	3.8	0.0	0.6	0.9
EL-500				
unmowed	7.2	0.0	0.6	-0.9
mowed	5.0	0.1	0.6	-0.9
Control				
unmowed	6.3	0.6	0.5	0.9
mowed	5.3	0.1	0.5	0.3
Comparisons:				
Unmowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	
Mowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 19

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN, 10 WEEKS AFTER MAY PLUS JUNE TREATMENT.

Treatment	% Sol. TNC	% Insol. TNC	% Total N	Corr. Coef.
Mefluidide				
unmowed	3.7	0.0	0.7	0.9
mowed	5.3	0.0	0.9	-0.4
EL-500				
unmowed	2.8	0.0	0.7	0.9
mowed	3.9	0.0	0.8	-0.8
Control				
unmowed	5.1	0.0	0.7	-0.6
mowed	4.8	0.0	0.7	0.5
Comparisons:				
Unmowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	*	ns	ns	
Mowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR UNMOWED PLOTS 5 WEEKS AFTER MAY AND JUNE TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	99354379	99354379	373.02	
Trt	2	767984	383992	1.44	0.3377
Block	2	553126	276563	1.04	0.4333
Resid	4	1065414	266353	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR UNMOWED PLOTS 10 WEEKS AFTER MAY AND JUNE TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	36574272	36564272	400.12	
Trt	2	1307668	653834	7.15	0.0477
Block	2	144620	72310	0.79	0.5135
Resid	4	365631	91408	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR MOWED PLOTS 5 WEEKS AFTER MAY AND JUNE TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	53719127	53719127	350.81	
Trt	2	1216406	608203	3.97	0.1122
Block	2	1241363	620681	4.05	0.1092
Resid	4	612520	153130	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR MOWED PLOTS 10 WEEKS AFTER MAY AND JUNE TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	44257974	44257974	300.58	
Trt	2	920220	460110	3.12	0.1523
Block	2	541324	270662	1.84	0.2715
Resid	4	588967	147242	1.00	

TABLE 20

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN, 5 WEEKS AFTER SEPTEMBER TREATMENT

Treatment	% Sol. TNC	% Insol. TNC	% Total N	Corr. Coef.
Mefluidide				
unmowed	9.3	0.0	0.8	0.8
mowed	7.8	0.0	0.8	0.9
EL-500				
unmowed	11.6	0.0	0.7	-0.9
mowed	9.9	0.2	0.7	-0.9
Control				
unmowed	12.5	1.8	0.7	0.1
mowed	9.6	0.6	0.7	0.7
Comparisons:				
Unmowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	*	ns	
Mowed:				
Mef vs EL-500	ns	ns	ns	
Chem vs Control	ns	ns	ns	

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR UNMOWED PLOTS 5 WEEKS AFTER SEPTEMBER TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	282382468	282382468	240.87	
Trt	2	5826027	2913014	2.48	0.0431
Block	2	1915707	957853	1.63	0.4444
Resid	4	4689220	1172305	1.00	

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR MOWED PLOTS 5 WEEKS AFTER SEPTEMBER TREATMENT.

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	187980576	187980576	291.79	
Trt	2	2108354	1054177	1.63	0.2612
Block	2	4119317	2059658	3.19	0.1155
Resid	4	2576903	644225	1.00	

APPENDIX B

TABLE 21

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN FOR MEFLUIDIDE TREATED TURF AND CONTROLS AT LOW TEMPERATURE (21C/13C, LIGHT/DARK).

	Weeks in Growth Chamber				
	0	1	2	3	4
%SOL.TNC					
Mefluidide	5.0	5.7	6.0	7.6	4.6
Control	5.0	4.5	3.9	5.1	4.5
%INSOL. TNC					
Mefluidide	0.3	0.1	0.0	0.0	0.8
Control	0.3	0.2	0.1	0.3	0.3
%TOTAL N					
Mefluidide	0.8	0.8	0.9	0.6	0.6
Control	0.8	0.7	0.7	0.5	0.5
Comparisons:					
Chem vs Cont (Sol)	ns	**	**	**	ns
Chem vs Cont (Insol)	ns	ns	ns	ns	ns
Chem vs Cont (total N)	ns	ns	**	ns	ns
Corr. Coef. TNC:TN (over 5 week period)					
Mefluidide	-0.5				
Control	-0.5				

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 22

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN FOR EL-500 TREATED TURF AND CONTROLS AT LOW TEMPERATURE (21C/13C, LIGHT/DARK).

	Weeks in Growth Chamber				
	0	1	2	3	4
%SOL.TNC					
EL-500	7.6	8.9	4.7	4.7	4.5
Control	7.6	7.6	4.5	4.5	4.3
%INSOL. TNC					
EL-500	0.2	0.0	0.9	0.0	0.0
Control	0.2	2.0	0.6	0.0	0.0
%TOTAL N					
EL-500	0.7	0.6	0.7	0.8	0.7
Control	0.7	0.7	0.8	0.8	0.7
Comparisons:					
Chem vs Cont (Sol)	ns	ns	ns	ns	ns
Chem vs Cont (Insol)	ns	**	ns	ns	ns
Chem vs Cont (Total N)	ns	ns	ns	ns	ns

Corr. Coef. TNC:TN
(over 5 week period)

EL-500	-0.7
Control	-0.7

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

TABLE 23

PERCENT SOLUBLE AND INSOLUBLE TNC, AND CORRELATION COEFFICIENT BETWEEN TNC AND TOTAL NITROGEN FOR EL-500 TREATED TURF AND CONTROLS AT HIGH TEMPERATURE (35C/24C, LIGHT/DARK).

	Weeks in Growth Chamber				
	0	1	2	3	4
%SOL.TNC					
EL-500	7.6	6.6	5.2	5.0	5.1
Control	7.6	9.3	5.0	4.7	5.9
%INSOL. TNC					
EL-500	0.2	0.0	0.0	0.0	0.0
Control	0.2	0.0	0.0	0.0	0.0
%TOTAL N					
EL-500	0.7	0.7	0.8	0.7	0.7
Control	0.7	0.7	0.8	0.8	0.8
Comparisons:					
Chem vs Cont (Sol)	ns	ns	ns	ns	ns
Chem vs Cont (Insol)	ns	ns	ns	ns	ns
Chem vs Cont (Total N)	ns	ns	ns	ns	ns

Corr. Coef. TNC:TN (over 5 week period)

EL-500	-0.3
Control	-0.7

Ns, *, **: No significance, significant at the 0.05 and 0.01 levels, respectively.

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR MEFLUIDIDE TREATED TURF AND CONTROLS AT LOW TEMPERATURE (21C/13C, light/dark).

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	220707988	220707988	738.72	
Trt	1	2671874	2671874	8.94	0.0173
Week	4	2386531	596633	2.00	0.1880
Rep	2	49370	24685	0.08	0.9215
Trt,Wk	4	1429270	357317	1.20	0.3829
Trt,Rep	2	6662	3331	0.01	0.9889
Wk,Rep	8	1784139	223017	0.75	0.6555
Trt,Wk,Rep	8	2390159	298770	1.00	0.5000

ANALYSIS OF VARIANCE OF SOLUBLE AND INSOLUBLE CARBOHYDRATES FOR EL-500 TREATED TURF AND CONTROLS AT LOW AND HIGH TEMPERATURE (21C/13C, 35C/24C, light/dark).

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	533906154	573906154	2225.7	
Trt	1	285798	285798	1.1	0.2985
Week	4	42941098	10735275	41.6	0.0000
Temp	1	100778	100778	0.4	0.5352
Rep	2	1592844	796422	3.1	0.0560
Trt,Wk	4	2422013	605503	2.3	0.0698
Trt,Temp	1	359910	359910	1.4	0.2441
Temp, Wk	4	2916809	729202	2.8	0.0365
Residual	42	10829864	257854	1.0	

ANALYSIS OF VARIANCE AT WEEK 1 OF INSOLUBLE CARBOHYDRATES FOR EL-500 TREATED TURF AND CONTROLS AT LOW AND HIGH TEMPERATURE (21C/13C, 35C/24C, light/dark).

Source	DF	Sum Sq	Mean Sq	F-Value	Prob (F)
Mean	1	946970	946970	132.67	
Trt	1	946730	946730	132.67	0.0075
Temp	1	946970	946970	132.67	0.0075
Rep	2	14275	7138	1.00	0.5000
Trt,Temp	1	946730	946730	1.00	0.0075
Trt,Rep	2	14275	7138	1.00	0.5000
Temp,Rep	2	14275	7138	1.00	0.5000
Trt,Temp,Rep	2	14275	7138	1.00	0.5000